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(54) Image positional relation correction apparatus, steering supporting apparatus provided with the image positional relation correction apparatus, and image positional relation correction method

(57) An image positional relation apparatus is provided, in which coordinate data of a real target photographed by a CCD camera and coordinate data of a virtual target logically calculated from the predetermined position of the real target are transmitted to a superimpose circuit, and the real target and the virtual target are superimposed to be displayed on a monitor screen. A user operates a controller so that the real target coincides with the virtual target. An amount of such operation is transmitted to the superimpose circuit as a correction amount, and the positional relation between the real target and the virtual target, i.e., the positional relation between the real image and the virtual image can be properly corrected.

FIG. 1

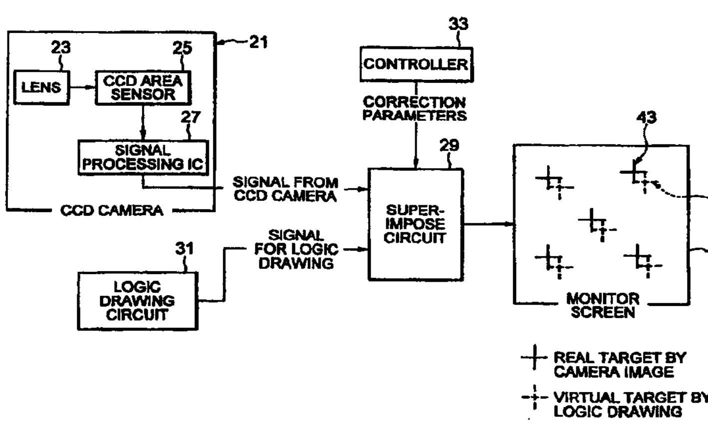

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image positional relation correction method for correcting the relative positional relation between a real image taken by a camera and a virtual image to be superimposed to be displayed on a monitor screen together with the real image comprising the steps of taking a real target by a camera, setting a virtual target theoretically derived from the coordinates of the real target on the same coordinate system as the virtual image, and correcting the relative relation between the real image and the virtual image based on the deviation between the real target and the virtual target.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011]

Fig. 1 is a block diagram illustrating an outline of an image positional relation correction apparatus in accordance with a first embodiment of the present invention;
Fig. 2 is a view schematically illustrating a controller of an image positional relation correction apparatus in accordance with the first embodiment of the present invention;
Fig. 3 is a view schematically illustrating the state in which a test chart member as real target providing means is mounted on the rear part of a vehicle;
Fig. 4 is a block diagram illustrating the outline of an image positional relation correction apparatus in accordance with a second embodiment of the present invention;
Fig. 5A is a side view showing the state in which an image positional relation correction apparatus in accordance with a fourth embodiment of the present invention is mounted on a vehicle;
Fig. 5B is a plan view showing the state in which an image positional relation correction apparatus in accordance with the fourth embodiment of the present invention is mounted on a vehicle;
Fig. 6A is a side view showing the state in which an image positional relation correction apparatus in accordance with the fourth embodiment of the present invention is mounted on a vehicle;
Fig. 6B is a plan view showing the state in which an image positional relation correction apparatus in accordance with the fourth embodiment of the present invention is mounted on a vehicle;
Fig. 7 is a block diagram illustrating an outline of an image positional relation correction apparatus in accordance with the fourth embodiment of the present invention;
Fig. 8 is a block diagram illustrating an outline of an image positional relation correction apparatus in accordance with a fifth embodiment of the present invention;
Fig. 9 is a block diagram illustrating an outline of an image positional relation correction apparatus in accordance with a sixth embodiment of the present invention;
Fig. 10A illustrates a monitor screen of a conventional steering supporting apparatus in the normal state in which the optical axis of a lens coincides with the center of a CCD area sensor; and
Fig. 10B illustrates a monitor screen of a conventional steering supporting apparatus in the state in which the optical axis of the lens and the center of the CCD area sensor deviate.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] An embodiment in which an image positional relation correction apparatus of the present invention is applied to the case for correcting the image positional relation between a vehicle rear image and a steering supporting guide in a steering supporting apparatus of a vehicle will be hereinafter described with reference to the accompanying drawings.

First Embodiment

[0013] Fig. 1 is a block diagram illustrating the outline of an image positional relation correction apparatus in accordance with a first embodiment of the present invention. A CCD camera 21 is provided with a lens 23, a CCD area sensor 25 and a signal processing IC 27. A signal from the signal processing IC 27 is to be inputted in a superimpose circuit 29. Moreover, a signal from a logic drawing circuit 31 and a correction signal from a controller 33 are also to be inputted in the superimpose circuit 29. A signal from the superimpose circuit 29 is to be outputted to a monitor 35. In addition, as shown in Fig. 2, the controller 33 consists of a housing, and a cross button 37 capable of inputting a correction amount in the upward, downward, leftward and rightward directions is provided on its front face.
[0014] Operations of the image positional relation correction apparatus in accordance with this embodiment will now be described. First, as shown in Fig. 3, the CCD camera 21 for taking a vehicle rear image as a real image is mounted on the rear part of a vehicle 39. In addition, the front end of a test chart member 41 as real target providing means is attached to a rear bumper 39a of the vehicle 39. In this way, the test chart member 41 is disposed within an object area A of the CCD camera 21. Five cross-shaped real targets 43 are drawn on the upper surface of the plate-like test chart member 41. A real image including the real target 43 is taken in from the CCD area sensor 25 via the lens

like. In this way, even if the optical axis of the lens 23 does not coincide with the center of the CCD area sensor 25, the positional relation between the vehicle rear image as a real image and the steering supporting guide as a virtual image can be made proper.

Third Embodiment

[0022] Although the correction amount inputted in the controller 33 is transmitted to the superimpose circuit 29 in the first embodiment, in the third embodiment, the correction amount inputted in the controller 33 is transmitted to the CCD camera, for example, via a serial interface of the CCD camera, and image data correction is performed in the CCD camera. In such a form, as in the first embodiment, the positional relation between the vehicle rear image as a real image and the steering supporting guide as a virtual image can be made proper.

Fourth embodiment

[0023] An image positional relation correction apparatus in accordance with a fourth embodiment corrects the relative positional relation between a real image and a virtual image in the case in which not only the optical axis of the lens does not coincide with the center of the CCD sensor area, but the CCD camera is not properly mounted on a vehicle as prescribed by the standard.

[0024] First, the state in which the image positional relation correction apparatus in accordance with this fourth embodiment is mounted on a vehicle will be described. As shown in Figs. 5A and 5B, the CCD camera 21 for taking a vehicle rear image is mounted on the rear part of the vehicle 39. The CCD camera 21 is provided with the lens 23 and the CCD area sensor 25. In addition, a monitor 65 is provided in the front of the driver's seat of the vehicle 39.

[0025] An ideal state in which the CCD camera 21 is mounted on the vehicle as prescribed by the standard and an optical axis 77 of the lens 23 of the CCD camera 21 coincides with the center of the CCD area sensor 25 will be described.

[0026] For the convenience of description, a road surface coordinate system is assumed where a point on the ground vertically down from a rear axle center 75 of the vehicle to a road surface 76 is assumed to be an origin O , a horizontal direction toward the rear of the vehicle 39 is assumed to be a y axis positive direction, a horizontal direction toward the left of the vehicle 39 is assumed to be an x axis positive direction, and a vertical direction upward of the vehicle 39 is assumed to be a z axis positive direction.

[0027] The CCD camera 21 is disposed on the standard mounting position of a coordinate point PS (x, y, z) displayed the road surface coordinate system with a standard mounting angles of a depression angle ω, a direction angle γ and a rotation angle θ. Here, the depression angle ω represents an angle downward from a y axis direction, the direction angle γ represents an angle from a y axis negative direction on a surface parallel with a x-y plane, and the rotation angleθ is an angle with which the CCD camera 21 is rotated around the optical axis center 77 to be amounted.

[0028] In addition, the positional deviation amount to the x axis positive direction of the center of the CCD area sensor 25 against the optical axis 77 of the lens 23 is assumed to be ΔCx, and the positional deviation amount to the y axis positive direction is assumed to be ΔCy. Here, x, y, z, ω, γ, θ, ΔCx and ΔCy are assumed to be standard mounting parameters even if they are predetermined values.

[0029] Particularly, the optical axis 77 of the lens 23 of the CCD camera 21 and the center of the CCD area sensor 25 are positionally adjusted in the state in which they coincide with each other. That is, both the positional deviation amount ΔCx to the x axis positive direction and the positional deviation amount Δcy to the y axis positive direction of the CCD area sensor 25 against the optical axis 77 of the lens 23 are 0.

[0030] On the other hand, as shown in Fig. 6A and 6B, if the CCD camera 21 is actually mounted on the vehicle 39, the CCD camera 21 is mounted with a mounting error against the standard, and the optical axis 77 of the lens 23 of the CCD camera 21 does not coincide with the center of the CCD area sensor 25.

[0031] In this case, the CCD camera 21 is disposed in the mounting position of a coordinate point PC (x+Δx, y+Δy, z+Δz) represented by the road surface coordinate system with the mounting angles of the depression angle $\omega+\Delta\omega$, the direction angle $\gamma+\Delta\gamma$ and the rotation angle $\theta+\Delta\theta$.

[0032] In addition, the positional deviation amount to the x axis positive direction of the CCD area sensor 25 is ΔCx, and the positional deviation amount to the y axis positive direction is ΔCy.

[0033] Here, x+Δx, y+Δy, z+Δz, $\omega+\Delta\omega$, $\gamma+\Delta\gamma$, $\theta+\Delta\theta$, ΔCx and Δ Cy are assumed to be actual mounting parameters.

[0034] In addition, a test chart member 81 is disposed in a predetermined position that is apart from the origin O on the road surface in the backward direction of the vehicle 39 by a predetermined distance. The test chart member 81 is to be disposed in the object area A of the CCD camera 21. In addition, a real target 83 formed of a rectangular with four standard points Q1, Q2, Q3 and Q4 as vertexes is drawn on the upper surface of the test chart member 81.

[0035] Fig. 7 is a block diagram illustrating an outline of an image positional relation correction apparatus in accordance with an embodiment of the present invention. The CCD camera 21 is provided with the lens 23, the CCD area sen-

deviation amount ΔCx and ΔCy between the optical axis 77 and the lens 23 and the center of the CCD area sensor 25 are assumed to be eight parameters x1 through x8 respectively, and the coordinate values of the road surface coordinate system of the standard point Q are assumed to be X_Q and Y_Q.

[0045] The x, y coordinates of the image standard point P1, the x, y coordinate of P2, x, y coordinates of P3, and the x, y coordinates of P4 are assumed to be ξ1 through ξ8 respectively in this order, and is represented by a general equation ξn (provided that n is an integer number from 1 to 8).

[0046] For example, since X_Q and Y_Q are given as constants by the coordinate value of the standard point Q1, the x coordinates of the image standard point P1 is represented as follows:

$$\xi 1 = F1\ (x1, x2, x3, x4, x5, x6, x7, x8)$$

[0047] In addition, concerning the coordinates of the image standard points P1 through P4 photographed in a real camera mounting state and shown on the monitor as shown in Figs. 6A and 6B, the x, y coordinates of P1, the x, y coordinates of P2, the x, y coordinates of p3, and the x, y coordinates of P4 are assumed to be ξ1' through ξ8' and is represented by a general equation ξn' (provided that n is an integer number from 1 to 8).

[0048] The x coordinates and the y coordinates ξ1' through ξ8' of the image standard points P1 through P4 are already calculated by the controller 63.

[0049] Here, if the function fn (x1, ..., x8) = ξn - ξn' is introduced, and the values of the real mounting parameter being the real camera mounting state is set, fn (x1, ..., x8) = 0.

[0050] That is, if the values of the parameters x1 through x8 is calculated so that any of f1 through f8 is 0, these values become the values of the real mounting parameter.

[0051] The Newton-Raphson method is used in calculating the parameters x1 through x8.

[0052] When the Taylor's expansion expression is introduced with respect to the function fn, approximation can be found as follows:

$$fn\ (x1 + \Delta x1, \ldots, x8 + \Delta x8) = fn\ (x1, \ldots, x8) + dfn/dxn \bullet \Delta xn = 0$$

Therefore,

$$\begin{aligned} dfn/dxn \bullet \Delta xn &= -fn\ (x1, \ldots, x8) \\ &= -(\xi n - \xi n') \\ &= -(Fn\ (x1, \ldots, x8) - \xi n') \\ &= \xi n' - Fn\ (x1, \ldots, x8) \end{aligned}$$

[0053] In addition, dfn/dxn = dFn/dxn and

$$dFn/dxn \bullet \Delta xn = \xi n' - Fn\ (x1, \ldots, x8) \qquad (1)$$

[0054] Here, the equation (1) is represented as a matrix, the ideal standard mounting parameters as shown in Figs. 5A and 5B are substituted in x1 through x8 as initial values, and dFn/dxn and Fn are calculated. Since ξn' has been found as described above, Δx1 through Δx8 can be calculated. Then, the values of x1 through x8 are corrected by adding Δx1 through Δx8 to x1 through x8 respectively and are substituted in the equation (1) to find Δ x1 through Δx8. By repeating this processing until Δx1 through Δx8 become 0 or a predetermined value in the vicinity of 0, the real mounting parameters x1 through x8 can be found.

[0055] In this way, the real mounting parameters are calculated, and the logic drawing circuit 61 calculates new virtual target points R1 through R4 based on the real mounting parameters to display the new virtual target points R1 through R4 on the monitor screen 65 again. In addition, since data of the virtual image, for example, display data of the steering supporting guide, in the same coordinate system as the virtual target 85, are prepared again, the positional relation between the real image and the virtual image can be properly corrected.

[0056] With this processing, even if the optical axis 77 of the lens 23 does not coincide with the center of the CCD area sensor 25 and the CCD camera cannot be mounted on the vehicle properly as prescribed by the standard, the positional relation between the real image and the virtual image can be properly corrected without physically adjusting the optical axis 77 of the lens 23 and without performing adjustment work for mounting the CCD camera on the vehicle with high accuracy as prescribed by the standard. That is, the positional relation between a vehicle rear image as the real image and a steering supporting guide as the virtual image can be made proper.

on the vehicle or disposed on a road surface but may be white lines drawn on the road surface. In addition, the number and the shape of real targets provided on the test chart member are not limited to those shown in the above-mentioned embodiments. Moreover, real target providing means is not necessarily a member separate from the vehicle like the test chart member, but a part of the vehicle in the object area of a camera may be assumed to be the real target.

[0066] In addition, although the controller 33 and the cross button 37 are used for operation in the above-mentioned first embodiment, and the touch panel is used in the fourth and the sixth embodiments, operating means is not limited to these but may be any means operable to overlap a virtual target point and an image standard point. Operation procedures are not limited to the foregoing as well, but various procedures may be implemented within the scope not deviating from the purport of this invention.

[0067] Further, although a virtual image by logic drawing is corrected in the above-mentioned first embodiment and a real image photographed by a CCD camera is corrected in the second embodiment, the method of correction is not limited to these but such forms may be possible as to correct the real image photographed by the CCD camera in the first embodiment and to correct the virtual image by logic drawing in the second embodiment.

[0068] Moreover, the above-mentioned embodiments are described concerning the case in which the embodiments are applied to the correction of images in a steering supporting apparatus of a vehicle, an image positional relation correction apparatus of the present invention is not limited to this but may be applied to image correction in other apparatuses for superimposing to display a real image and a virtual image.

[0069] Furthermore, if a CCD camera is mounted on a vehicle as prescribed by the standard, the Newton-Raphson method may be applied only to the deviation amount of the center of a CCD sensor area against the optical axis of a lens. On the other hand, if the deviation amount of the center of the CCD sensor area against the optical axis of the lens is known or there is no deviation amount, the Newton-Raphson method may be applied to six parameters of the positions and the angles for mounting the CCD camera to the vehicle.

[0070] If a deviation between a real image and a virtual image arises due to such factors as the focal length and skewness of a lens, and dispersion of the inclination of the light receiving surface of a CCD area sensor against the optical axis of the lens, the focal length and skewness of the real lens, and the inclination of the light receiving surface of the CCD sensor against the optical axis of the lens may be calculated by adding the factors in parameters and applying the Newton-Raphson method.

[0071] In addition, although the rectangular virtual target 95 with the virtual target points R1 through R4 is used in the sixth embodiment, virtual targets are not limited to these but additional virtual target points R5, R6, ... may be used. In this case, the virtual target points R1 through R4 may be shifted so that the additional virtual target points R5, R6, ... overlap additional standard points Q5, Q6, ... as in the sixth embodiment, or the difference amount between the additional virtual target points R5, R6, ... and the additional image standard points Q5, Q6, ... may be grasped by moving the R5, R6, ... directly. The amount by which the virtual target points R1 through R4 should be shifted can be calculated based on the grasped difference amount. In this way, since the repetition of an operator's adjustment operation, namely, [shift] → [match determination] → [shift] → [match determination], becomes unnecessary, and operation time can be reduced and, at the same time, correction with high accuracy becomes possible.

[0072] Moreover, the image processing circuit used in the fifth embodiment may be added to the image positional relation correction apparatus of the sixth embodiment to coincide a virtual target with a real target more accurately by operating the controller to the rectangular virtual target displayed as a result of the image processing.

[0073] Further, since the screen of the monitor displays by the unit of one dot, coordinates with the accuracy of less than one dot unit cannot be calculated if the virtual target has four points. However, if not only four points but also a rectangular shape is displayed as the virtual target, as the image positional relation correction apparatus of the sixth embodiment, the logic drawing circuit may define coordinate data of each point on the rectangular using the coordinates corresponding to 0.1 dot of the monitor screen. If a rectangular shape based on the coordinate data with accuracy higher than the dot of the monitor screen, the coordinates of the real target on the monitor screen can be obtained with higher accuracy due to the degree of linear deviation of the sides of the rectangular.

[0074] Moreover, a virtual target may be one that not only displays a position corresponding to a real target but also displays a position where an optical axis of a lens of a camera reaches a road surface.

[0075] An image positional relation apparatus is provided, in which coordinate data of a real target photographed by a CCD camera and coordinate data of a virtual target logically calculated from the predetermined position of the real target are transmitted to a superimpose circuit, and the real target and the virtual target are superimposed to be displayed on a monitor screen. A user operates a controller so that the real target coincides with the virtual target. An amount of such operation is transmitted to the superimpose circuit as a correction amount, and the positional relation between the real target and the virtual target, i.e., the positional relation between the real image and the virtual image can be properly corrected.

setting a virtual target logically led from the coordinates of said real target on the same coordinate system as said virtual image; and

correcting the relative positional relation between said real image and said virtual image based on the deviation between said real target and said virtual target.

FIG. 2

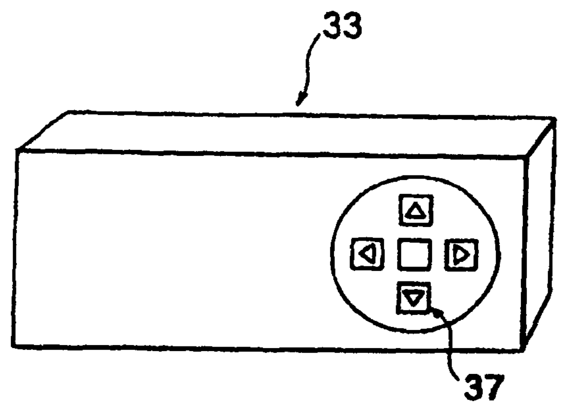


FIG. 3

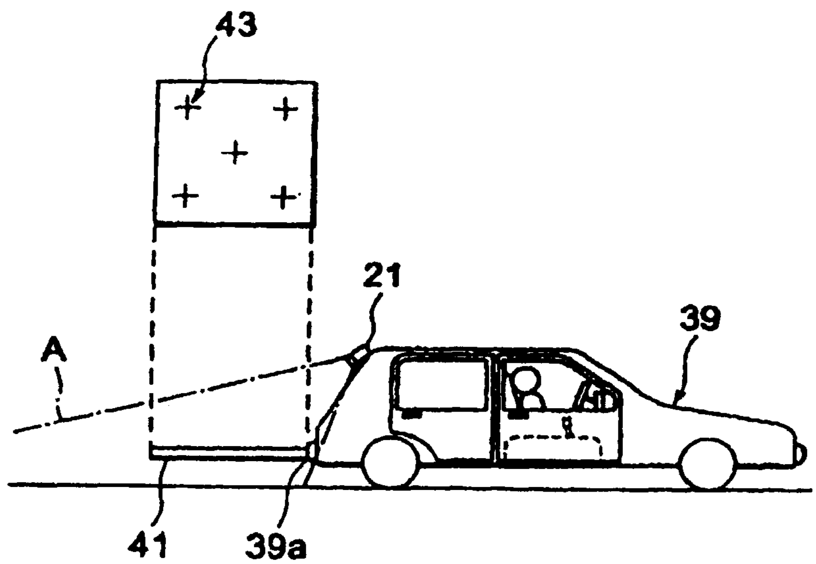


FIG. 7

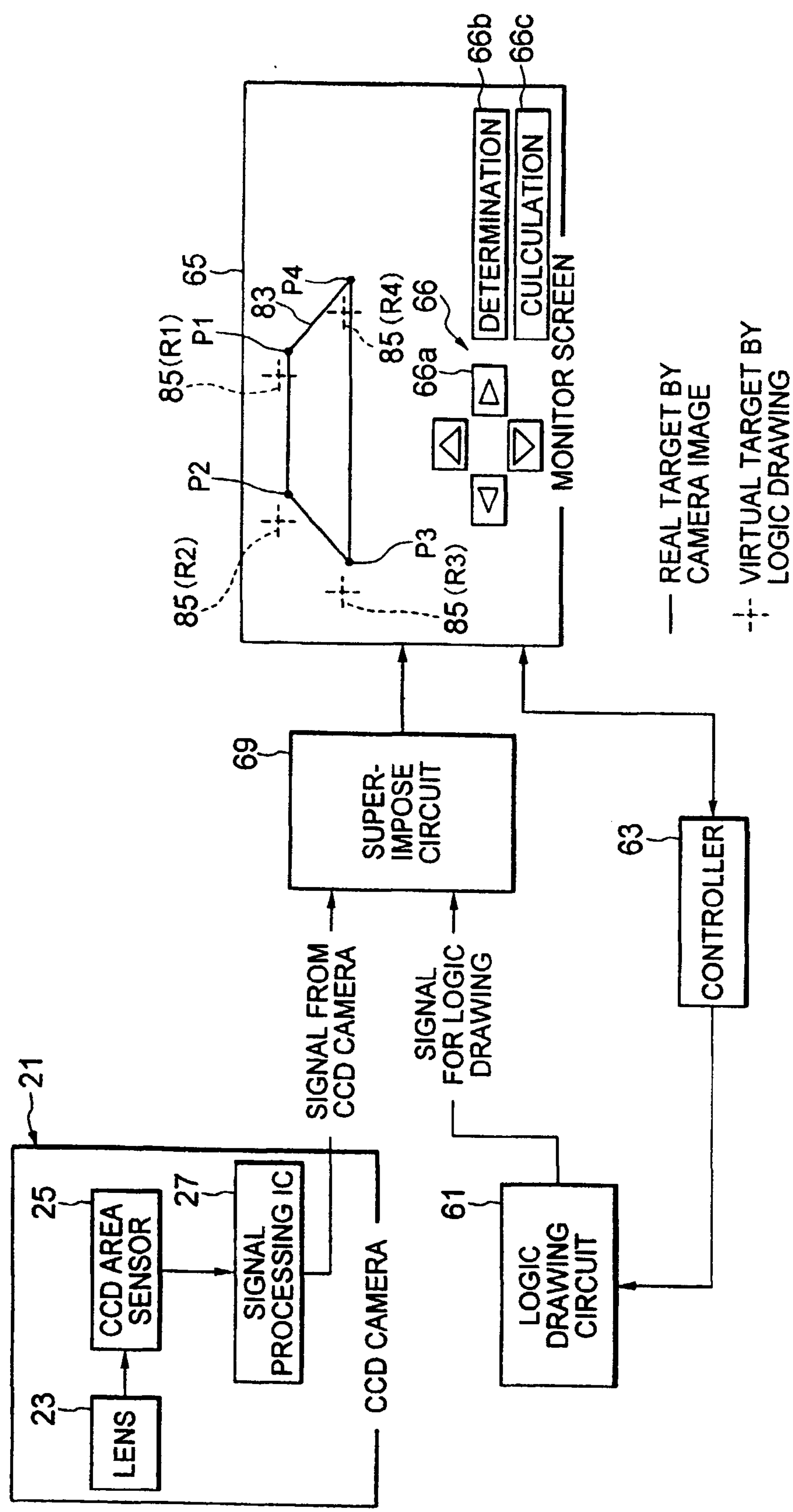
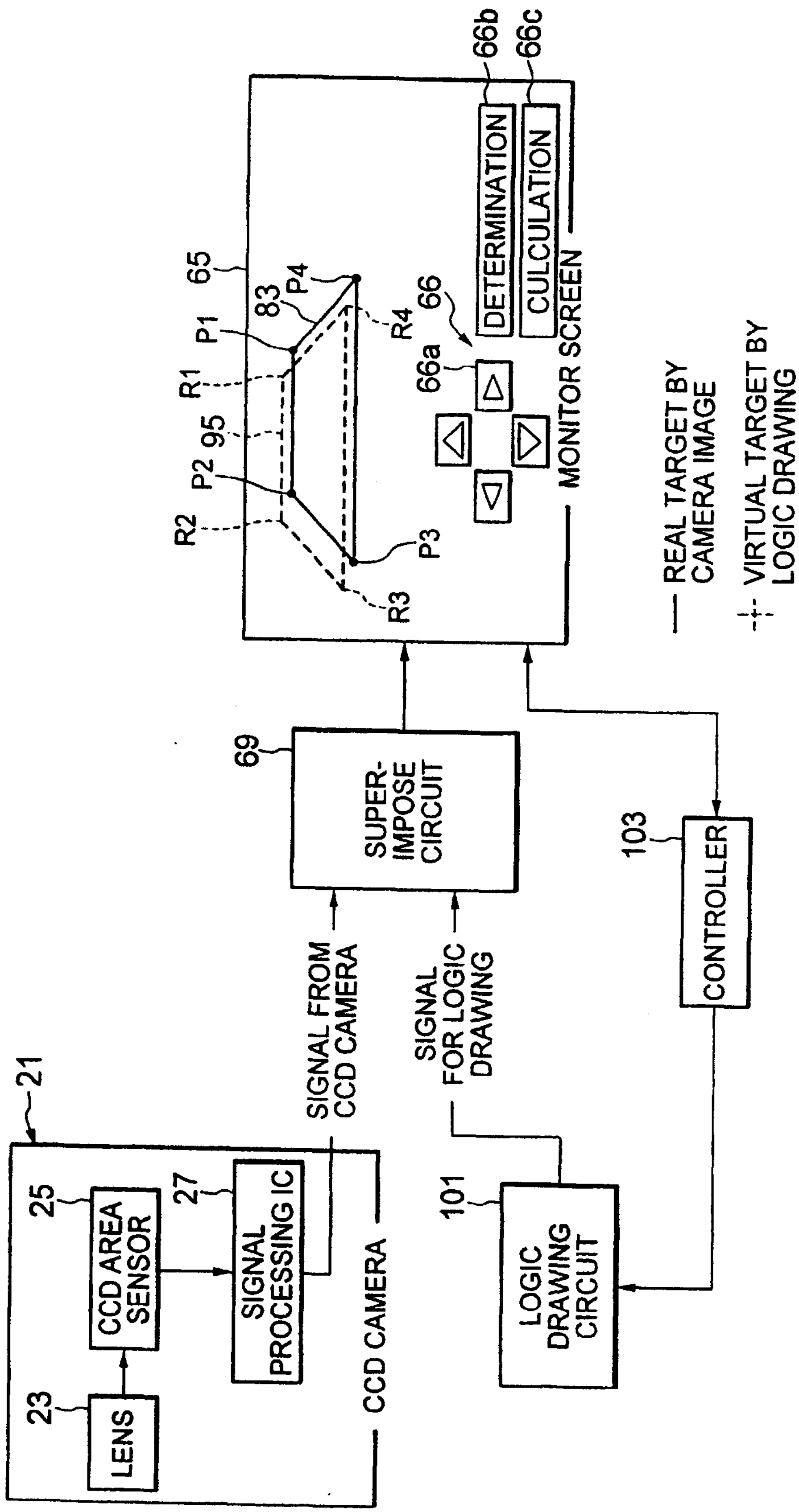

21
23
LENS
25
CCD AREA SENSOR
27
SIGNAL PROCESSING IC
CCD CAMERA
SIGNAL FROM CCD CAMERA
SIGNAL FOR LOGIC DRAWING
61
LOGIC DRAWING CIRCUIT
69
SUPER-IMPOSE CIRCUIT
63
CONTROLLER
65
P1
P2
P3
P4
83
85(R1)
85(R2)
85(R3)
85(R4)
66
66a
66b
66c
DETERMINATION
CULCULATION
MONITOR SCREEN
REAL TARGET BY CAMERA IMAGE
VIRTUAL TARGET BY LOGIC DRAWING

FIG. 9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LENS
23
CCD AREA SENSOR
25
SIGNAL PROCESSING IC
27
CCD CAMERA
SIGNAL FROM CCD CAMERA
SIGNAL FOR LOGIC DRAWING
LOGIC DRAWING CIRCUIT
101
SUPER-IMPOSE CIRCUIT
69
CONTROLLER
103
MONITOR SCREEN
65
R1
R2
R3
R4
P1
P2
P3
P4
95
83
66
66a
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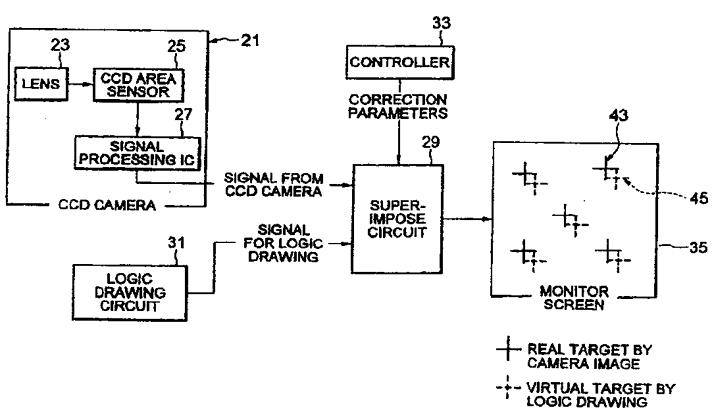
FIG. 1



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